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3 of 50-200 .ANG. of Ti, Nb, TiZr or Mo; the leads 24a, 24b of 500-2000 .ANG. of Ta with an underlying seed layer of TiW or TaW to reduce the resistivity; the shields 30, 32 of a magnetically permeable material, such as Permalloy; the insulating layers 26, 28 of an electrically insulating material such as Al.sub.2 O.sub.3 ; and the hard bias strips 34a, 34b of a hard magnetic (i.e., high coercivity) material such as CoPtCr having a thickness substantially equal to the combined thickness of layers 21, 22, 23.

(5) Spacer layer 21 (i) prevents the undesirable chemical reactions which can occur when a shunt layer is in direct contact with an MR layer; and (ii) acts as a seed layer, especially if of Ta, to provide superior MR material for layer 22.

(6) Current source 36 produces a current flow through the MR head 20 to provide proper biasing and to generate an output voltage signal. Sensing means 38 senses variations in resistivity of the MR head 20 due to differences in rotation of the magnetization M in MR layer 22 as a function of the magnetic field being sensed.

(7) Referring now also to FIG. 3, according to f

able dielectric material, a thin isolation layer 107 of Ta, an MR layer 109 of NiFe, a spacer layer 113 of Ta, a transverse bias layer 115 of NiFeNb and an antiferromagnetic stabilization layer 117 of NiO. Utilizing photolithographic and subtractive processing, the Ta/NiFe/Ta/NiFeNb/NiO layer stack is patterned to define the sensor central active region 116 and expose the surface of the insulation layer 105 in the sensor end regions 118. The longitudinal bias layer 111 followed by the conductive lead layer 119 are then deposited and patterned in the sensor end regions 118. As described above with reference to FIG. 8, the longitudinal bias field is provided by hard or permanent magnetic biasing with the directions of the longitudinal and transverse bias fields being set by magnetic saturation and low temperature annealing processes, respectively, as described above.

(23) As described above with reference to FIGS. 3 and 6, the use of an antiferromagnetic NiO stabilization layer in combination with a NiFeNb transverse bias layer minimizes or eliminates the magnetic instability exhibited by prior art MR heads as shown in FIG. 4. A potential problem that arises is that if the exchange coupling between the NiO layer and the NiFeNb layer is lost or reduced for some reason, then the NiFeNb soft layer may revert to the unstable magnetic behavior. It has been shown that sensor current transients due to electrical overs

e MR sensor 120 is temperature stabilized by providing a heat sink for the NiO stabilization layer 137 thus increasing the sensor current value at which the NiO layer reaches its blocking temperature. The structure of the MR sensor 120 is similar to the structure of MR sensor 80 described with reference to FIG. 8. MR sensor 120 comprises an MR layer 131 of NiFe, a spacer layer 133 of Ta and a transverse layer 135 of NiFeNb stabilized by exchange coupling to a stabilization layer 137 of NiO in the central active region 128 of the sensor. Longitudinal biasing of the sensor is provided by hard bias layer 127 of CoPtCr, for example, formed in the sensor end region 126. Conductive leads 129 of Ta or other suitable conductive material are provided in the sensor end region 126 deposited over the hard bias layer 127. The sensor is deposited on a suitable substrate 121 including magnetic shield layer 123. A heat sink layer 139 in contact with the NiO stabilization layer 137 separates the NiO layer from the magnetic shield 123. As shown in FIG. 10, in this preferred embodiment the NiO stabilization layer 137 and the heat sink layer 139 are patterned to be in the sensor central active region 128 only. An insulating layer 125 of dielectric material, such as alumina, for example, forms the gap region between the sensor end region 126 and the magnetic shield layer 123. Alternatively, the NiO stabilization layer 137 and the heat sink layer 139 can extend the entire length of the sensor being formed in both the sensor end region 126 and the central active region 128. Any

tering techniques. First a suitable substrate 81 including a first magnetic shield layer of Sendust covered with a layer of insulating material, such as alumina, for example, is prepared. Then the sensor active region layer structure NiO/NiFeNb/Ta/NiFe/Ta is deposited sequentially. Next, the sensor end region 76 is defined by photolithography and subtractively processed, such as by ion milling or etching, for example, to remove the thin Ta cap layer to expose the NiFe MR layer at the end regions.

The longitudinal bias layer 77 is deposited in the sensor end regions 76 in physical contact with the MR layer 75 over a thin seed layer of 74 of NiFe followed by the conductor lead structure of Ta/Au/Ta or other suitable lead material. Finally, the shape of the MR sensor in the central active region is defined by a second photolithographic patterning process followed by a subtractive removal process. The central active region 78 of the sensor is defined by the spaced-apart inner boundaries of the longitudinal bias and lead layers. This is a critical dimension as the length of the central active region determines the read trackwidth. An advantage of waiting until the leads have been deposited prior to defining the MR sensor shape is that the material forming the gap between the transverse bias layer 72 is protected from sensor fabrication process steps and damage due to over etching of the gap layer (i.e., the combined NiO stabilization layer

Oe, single state domain, seed layer

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SV sensor so that after the
annealing process at 280 C for about 2 hours to set the
Ni--Mn AFM layer
exchange coupling with the pinned layer, the SV sensor
exhibits a high GMR
coefficient, delta R/R, with high unidirectional anisotropy
field (H.sub.UA)

(14) Referring now to FIGS. 5a and 5b, the
magnetoresistance of SV sensors
fabricated with Ta seed and cap layers and with the
NiMnO.sub.x seed and cap
layers of the present invention, respectively, are shown
(the composition of
all other layers in the SV sensors were kept the same).
FIG. 5a is a graph of
the high field magnetoresistance hysteresis curves obtained
at room temperature
(RT) 510 and at 120 C 520 for a
Ta/Ni--Fe/Co/Cu/Co/Ni--Mn/Ta SV sensor after
annealing for 2 hours at 280 C. FIG. 5b is a graph of the
high field
magnetoresistance hysteresis curves obtained at RT 530 and
at 120 C 540 for a
NiMnO.sub.x /Ni--Fe/Co/Cu/Co/Ni--Mn/NiMnO.sub.y SV sensor
after annealing for 2
hours at 280 C. At RT, the GMR coefficient, delta R/R, of
6.3% for the SV
sensor fabricated with the NiMnO.sub.x seed and cap layers
is an improvement of
80% over the comparable SV sensor fabricated by the same
process but with Ta
seed and cap layers. At 120 C (typical SV sensor operating
temperature), the
delta R/R of 4.4% is an improvement of 69% over the SV
sensor with Ta seed and
cap layers. The unidirectional anisotropy field, H.sub.UA,
of 630 Oe and the
coercivity, H.sub.CE, of 291 Oe at 120 C remain nearly as
high as the values at
room temperature. These values are higher than those for
the SV sensor with Ta
seed and cap layers.

(15) Further annealing of the Ni--Mn AFM SV sensors with
Ta and NiMnO.sub.x
seed layers for up to 20 hours at 260 C does not cause any

bly perpendicular to the ABS. A cap layer 405, deposited on the AFM layer 430, completes the central region 402 of the SV sensor 400. In the present invention, the cap layer 405 is formed of nonmagnetic, electrically insulating NiMnO.sub.x.

(9) Referring to FIG. 4, the SV sensor 400 further comprises layers 434 and 436 formed on the end regions 404 and 406, respectively, for providing a longitudinal bias field to the free layer 410 to ensure a single magnetic domain state in the free layer. Lead layers 460 and 465 are also deposited on the end regions 404 and 406, respectively, to provide electrical connections for the flow of the sensing current I.sub.S from a current source 470 to the SV sensor 400. Sensing means 480 which is electrically connected to leads 460 and 465 sense the change in the free layer resistance due to changes induced in the free layer 410 by the external magnetic field (e.g., field generated by a data bit stored on a disk). The external magnetic field acts to rotate the direction of magnetization of the free layer 410 relative to the direction of magnetization of the pinned layer 420 which is preferably pinned perpendicular to the ABS. Sensing means 480 preferably includes a digital recording channel such as a PRML channel as is known to those skilled in the art. Se

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(Seed + material + hard bias + magnets ...)

filed 9/2001

918. FIG. 9 illustrates more
particularly one approach that was taken to improve the
hard magnet properties
of hard bias layer 135, which was to include a bi-layer
seed layer 910
underneath it. Bi-layer seed layer 910 included a first
seed layer 902
consisting of tantalum and a second seed layer 904
consisting of chromium.

(17) Although improved hard magnet properties were
exhibited with use of
bi-layer seed layer 910 of FIG. 9, relatively thick seed
layers (e.g.,
approximately 30 Angstroms of tantalum and 35 Angstroms of
chromium) were
required in order to achieve them. Such thick seed layers
are undesirable
because they increase the spacing between the hard magnet
and the free layer,
thereby decreasing the effectiveness of the hard magnet.

(18) Accordingly, what are needed are methods and
apparatus for improving
hard magnet properties in magnetoresistive read heads that
do not require the
use of thick s

m-chromium (200 Angstroms) structure versus a
tantalum-oxide (15Angstroms)/chromium (25
Angstroms)/cobalt-platinum-chromium
(200 Angstroms) structure.

(1) TABLE 1 Comparison of Coercivity. H.sub.c (Oe.)
with use of H.sub.c
(Oe.) with use of Seed Cr/CoPtCr Ta--O/Cr/CoPtCr NiFe (20
A) 342 700 NiFeCr
(20 A) 321 744

(22) As the data show, the hard magnet properties are
improved with use of
the inventive bi-layer seed layer.

(23) Table 2below provides data relating to the
insensitivity of the hard
magnet coercivity to the thickness of the bi-layered seed
layer. Here, an
oxidized tantalum (X Angstroms)/chromium (25
Angstroms)/cobalt-platinum-chromium (200 Angstroms)
structure was utilized on a
nickel-iron material (25 Angstroms).

(2) TABLE 2 Insensitivity of Hard Magnet Coercivity to
Tantalum Thickness.
Ta--O (X Angstroms) H.sub.c (Oe.) 5 720 10 700 15 700
20 710 25 700

(24) Thus, a magnetic head having improved hard magnet
properties has been
described. The magnetic head has a read sensor; a
multi-layered seed layer
formed adjacent the read sensor and over a contiguous
junction region of the
read sensor; and a hard bias layer formed over the
multi-layered seed layer.
The multi-layered seed layer includes a first seed layer
compri

6542341 (Grant filed date before 3/23/01

ion of the magnetization of the free layer can thus be electronically sensed and used in practical applications such as reading of magnetic data.

(6) An important concern in the design of the sensor is the longitudinal bias of the free layer. In particular, the free layer must be biased by a hard bias so that it is essentially in a single domain state. Deviations from a single domain state are mostly due to edge effects and corners and demagnetizing field effects as the sensor is excited by the external magnetic field. Also, the free layer has to be properly biased in the quiescent state to ensure a linear or essentially linear response with maximum dynamic range. When the free layer is allowed to have more than one magnetic domain, then the free layer experiences Barkhausen jumps and other domain reorientation phenomena, as is known in the art. This is highly undesirable as it produces noise and worsens the signal-to-noise ratio (SNR) of the sensor.

(7) In order to provide the biasing field and prevent noise some of the prior art sensors deploy a longitudinal

5696654 (Coer hard bias layer above 500 Oe)

ng to features of the invention, Cr layer 24 not only serves as a
seed layer for the CoPtCr layer 26 but also provides magnetic decoupling
between the NiMn antiferromagnetic layer 22 and the CoPtCr layer. The
antiferromagnetic layer 22 is exchange coupled to the NiFe layer 20 to provide
a longitudinal bias field in MR element MR1 of a magnitude of the order of at
least 20 Oersteds (Oe). The hard bias CoPtCr layer 26 preferably has a
coercivity above 500 Oe. Similarly MR element MR2 is longitudinally biased by
the hard bias CoPtCr layer 26. Since NiMn has a blocking temperature of about
400.degree. C., the direction of the exchange coupled magnetic field is set
during fabrication of sensor assembly 10 by annealing the NiFe/NiMn bilayer
20,22 at about 240.degree. C. in a magnetic field oriented along the
longitudinal axis of the MR element MR1 parallel to the sensor 10 air bearing
surface (ABS) and to the surface of an adjacent magnetic storage media (not
shown) as shown by arrow 33. The direction of magnetization of the hard bias
CoPtCr layer 26 is set at room temperature after fabrication of sensor 10 by
applying a large external magnetic field along the lon

20 of a magnetically soft ferromagnetic material substantially equal in thickness to that of MR1 deposited on substrate 12. Then, a layer 22 of antiferromagnetic material is deposited over and in contact with the ferromagnetic layer 20, followed by a thin layer 24 of a nonmagnetic metallic material. Next, a layer 26 of a hard magnetic bias material is deposited. The term "hard bias material" as herein used connotes a material, such as permanent magnet material, having high coercivity and high magnetization. Conductive leads 30a and 30b are then deposited over the hard bias layer 26. A layer 28 of suitable material is deposited between layer 26 and conductive leads 30a, 30b to reduce the resistance of the leads. The layers 20-30 are deposited so as to abut the MR elements MR1 and MR2 at the respective ends of the central active region 8 of the sensor 10. The length of the central active region 8 defines the track width of a data recording track formed on the surface of an associated magnetic storage media (not shown), the track edges being defined by the ends of the central active region 8.

(4) According to a preferred embodiment of dual element MR sensor 10 for use in a disk file (not shown), substrate 12 comprises Al.sub.2 O.sub.3 ; seed layer 14 is of Ta up to 40 .ANG. thick; elements MR1 and MR2 are of NiFe from 50 .ANG. to 300 .ANG. thick; high-resistivity conductive spacer layer 16 is of beta-phase Ta from 60 .ANG. to 1000 .ANG. thick; protective overcoat layer 18 is of Ta from 20 .ANG. to 40 .ANG.; layer 20 is of NiFe from 50 .ANG. to 300 .ANG. thick; layer 22 is of NiMn or NiO from 300 .ANG. to 600 .ANG. thick; layer 24 is of Cr from 50 .ANG. to 100 .ANG. thick; layer 26 is of CoPtCr from 200 .ANG. to 600 .ANG. thick; layer 28 is of

5869963 hard bias layer (Mr) of 0.9T and Coercive 1300 Oe

48 at %
Pt and 52 at % Mn (i.e., Pt.sub.48 Mn.sub.52).

(15) The above PtMn film was formed by the DC magnetron sputtering method using a PtMn alloy.

(16) The dual spin-valve type magnetoresistive sensor was subject to heat treatment (annealing) at 230.degree. C. This resulted in an exchange anisotropic magnetic field (Hex) of 470 Oe applied from the PtMn alloy film constituting the antiferromagnetic layer 4 to the FeNi alloy film constituting the pinned magnetic layer 3, and a coercive force (Hc) of 240 Oe in the pinned magnetic layer 3.

(17) Further, as shown in FIG. 1, CoPt alloy films with a thickness of 30 nm were formed as the hard bias layers 5 on both sides of the film laminate of the dual spin-valve type magnetoresistive sensor, and as shown in FIG. 13, CoPt alloy films with a thickness of 20 nm were formed as the hard bias layers 5 on both sides of the film laminate of the single spin-valve type magnetoresistive sensor. The hard bias layers 5 had each remanent magnetization (Mr) of 0.9 T (tesla) and a coercive force of 1300 Oe.

(18) When the film laminate was formed on a silicon substrate of 5 mm.times.25 mm, the dual spin-valve type magnetoresistive sensor showed a magnetoresistance ratio of 6.2% and sheet resistance of 10.8 .OMEGA./m.sup.2, while the single spin-valve type magnetoresistive sensor showed a magnetoresistance ratio of 3.9% and sheet resistance of 16.3 .OMEGA./m.sup.2.

(19) Thus, the magnetoresistance ratio of the dual spin-valve type magnetoresistive sensor was greater than that of the single

6538858 (Grant) filed before 3/23/01

alloy, i.e., permanent magnet films, are formed on both sides of the free magnetic layer 125. The hard bias layers 126 are formed for suppressing Barkhausen noise produced due to the formation of a plurality of magnetic domains in the free magnetic layer 125, and putting the free magnetic layer into a single magnetic domain state. For example, when the hard bias layers 126 are magnetized in the X1 direction shown in the drawing, magnetization of the free magnetic layer 125 is oriented in the X1 direction shown in the drawing by a leakage magnetic flux from the hard bias layers 126. This creates the relation that variable magnetization of the free magnetic layer 125 and fixed magnetization of the pinned magnetic layer 123 cross each other.

(20) In FIG. 18, reference numeral 128 denotes a conductive layer made of Cr, Ta, Au, or the like.

(21) In the spin-valve thin film element MR1, when the magnetization direction X1 of the free magnetic layer 125 is changed, electric resistance is changed with the angle with respect to the magnetization direction of the pinned magnetic layer 123 which is fixed in the Y direction, and a leakage magnetic field from the recording medium is detected

he substrate side.

(61) The terms "junction" means not only connection in direct contact the lamination but also connection therewith through, for example, a base layer, an intermediate layer, or the like.

(62) In the spin-valve thin film element, the upper surfaces of the hard bias layers are joined to the sides of the lamination at positions lower than the upper edges of the sides of the lamination. Therefore, a leakage magnetic flux from the hard bias layers is little absorbed by an upper shielding layer, thereby preventing a decrease in the effective magnetic field applied to the free magnetic layer, and easily putting the free magnetic layer into a single magnetic domain state. The spin-valve thin film element permits sufficient control of the magnetic domain of the free magnetic layer, and exhibits excellent stability.

(63) Also, in the spin-valve thin film element, the hard bias layers are arranged at the same level as the free magnetic layer to readily apply a strong bias magnetic field to the free magnetic layer, thereby easily putting the free magnetic layer into a single magnetic domain state, and decreasing the occurrence of Barkhausen noise.

(64) Furthermore, in the spin-valve thin film element, the upper surfaces of the hard bias layers are preferably joined to the sides of the lamination at the same positions as or positions lower than the uppermost position of the hard bias layers.

(65) In the spin-valve thin film element, therefore, a magnetic field exerting a magnetic field in the direction opposite to the

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nce of a longitudinal or transverse magnetic field of about 40 Oe to orient the easy axis of all of the ferromagnetic layers. The bottom lead layer 460 formed of gold (Au) having a thickness of about 100-500 .ANG. is deposited on a substrate 450 of preferably Al.sub.2 O.sub.3. The seed layer 440 formed of Cr. having a thickness of about 50 .ANG. is deposited on the lead 460. The AP-pinned layer 420 comprising the second ferromagnetic layer 430, the second interface layer 422, the APC layer 424, the first interface layer 426, and the first ferromagnetic layer 428 are sequentially deposited on the seed layer 440.

permanent magnet seed

(13) The second ferromagnetic layer 430 having a thickness of about 50 .ANG. is formed of Co.sub.80 -Pt.sub.12 -Cr.sub.8, a ferromagnetic material having high coercivity that gives it the properties of a hard permanent magnet. The second interface layer 422 is formed of cobalt (Co) having a thickness of about 5 .ANG.. The APC layer 424 is formed of ruthenium (Ru) having a thickness of about 6 A.

(14) The first interface layer 426 is formed of Co having a thickness of about 5 .ANG. and the first ferromagnetic layer 428 having a thickness of about 25 .ANG. is formed of Co.sub.30 -Fe.sub.70, a ferromagnetic material having high magnetization and therefore expected to have a high tunnel magnetoresistive coefficient.

(15) The tunnel barrier layer 415 is formed of Al.sub.2 O.sub.3 by depositing and then plasma oxidizing an 8-20 .ANG. aluminum (Al) layer on the first ferromagnetic layer 428.

(16) The free layer 410 comprising the first sub-layer

6466418 (permanent magnet hard bias layer + seed + material)

ickness, from shield to shield, of 0.13 microns, with a 400 angstrom thick SVMR stack, the lower substrate (12) is 570 angstroms thick and the upper substrate (24) is 330 angstroms thick. From device topographic and yield points of view, the width of the sensor track is best defined by a pair of patterned, contiguous (abutting) hard bias layers (25) formed of a hard ferromagnetic (permanent magnet) material such as CoPtCr, aligned upon a pair of electrical lead layers (26). It is to be noted that this method of defining the width of the sensor track leads to the formation of a "dead zone" (a region at the junction of the hard bias layer and SVMR stack where the magnetization runs parallel to the junction edge), making the top SVMR structure less suitable for decoding of ultra-high area density magnetic information.

(6) The magnetoresistive ratio (Dr/r) and signal amplitude (Dr) of the top SVMR can be enhanced by forming the first material seed layer (13) from NiFeCr or NiCr, rather than Ta. The use of a NiFeCr or NiCr seed layer produces specular reflection of the conduction electrons in the top SVMR, to which the enhancements can be attributed. In addition, the thermal stability (hence reliability) of the NiFeCr or NiCr based SVMR structure is better than that of the Ta based SVMR structure.

(7) Referring now to FIG. 2, there is shown a schematic drawing of the air-bearing surface (ABS) of a specularly reflecting, continuous spacer exchanged-biased bottom SVMR fabricated according to the methods of the present invention. Said bottom SVMR is positioned between the bottom shield (40) and top shield (60) of the read/write head structure, which region between the

6636397 (no Grant)

. The track width of the head is measured between the centers of the side surfaces of the free layer. In an effort to reduce the track width to submicron levels it has been found that the hard bias layers make the free layer magnetically stiff so that its magnetic moment does not freely respond to field signals from a rotating magnetic disk. Accordingly, there is a strong-felt need to provide submicron track width spin valve sensors which are still sensitive to the signals from the rotating magnetic disk along with longitudinal biasing of the free layer transversely so that the free layer is kept in a single magnetic domain state.

(10) SUMMARY OF THE INVENTION

(11) The present invention provides a submicron track width bottom spin valve sensor wherein the free layer is highly sensitive to field signals from a rotating magnetic disk even though the free layer is longitudinally biased for stabilization purposes. The spin valve sensor has a transverse length between the first and second side surfaces which is divided into a track

66 36396 (Giant)

sist is formed on top of multiple full film layers for the spin
valve sensor. These full film layers are then ion milled to form the spin
valve sensor with first and second side edges that are typically tapered at an
angle .theta. with respect to a normal to the planes of the layers. First and
second hard bias layers and first and second lead layers are then deposited
with the bilayer photoresist still in place forming what is known in the art as
contiguous junctions of the hard bias and lead layers with the first and second
side edges of the spin valve sensor. Magnetostatic fields from the first and
second hard bias layers are employed for the purpose of aligning the magnetic
moments of the free layer so that they are all in the same direction in a
single domain state. Without the hard bias layers the free layer is in a
multi-domain state with the magnetic domains being defined by numerous walls.
The narrower the track width the greater the magnetic instability of the free
layer. When the free layer is subjected to applied magnetic fields from the
rotating disk the domain walls move around which creates magnetic noise that is
superimposed upon the read signal.

(11) The aforementioned process of making contiguous junctions inherently
results in a taper of the first and second side edges of the layers of the
senso

6621666 (Giant)

and CoFe.

(12) The protection layer 14 prevents the resistivity of the TMR thin film 3 from rising and improves the crystal orientation of the free layer 13. The protection layer 14 is made of a metal material that is nonmagnetic and electrically conductive. Specific examples of materials that can be used for the protection layer 14 include Ta.

(13) The bias layers 4, 4 has the function of reducing the magnetic domains of the free layer 13 of the TMR thin film 3 to a single magnetic domain by applying a bias magnetic field to the TMR thin film 3 and preventing any magnetic wall from appearing. The bias layers 4, 4 are formed at longitudinal opposite ends of the TMR thin film 3 and made of a hard magnetic material showing a high electric resistivity. Preferably, the hard magnetic material shows an electric resistivity not lower than 0.5 .OMEGA.cm for the reasons as will be described below.

(14) Firstly, as shown in FIGS. 5 and 6, assume that the intensity of the electric current b that flows through the TMR thin film 3 is I1 when the intensity of the sense current a that is made to flow through the TMR element 1 is I and the resistance of the TMR thin film 3 is R1. Also assume that the intensity of the electric current c that flows through the bias layers 4, 4 is I2 and the resistance of the bias layers 4, 4 is R2. Then, if the level of the voltage d that is applied to the entire TMR element 1 is Vb, formula 1 below holds true. ##EQU1##

(15) The rat

6600638 (Gianu)

gnetic layer (FM1) 614, a second ferromagnetic layer (FM2) 618 and an antiparallel coupling (APC) layer 616 disposed between the FM1 layer 614 and the FM2 layer 618. The APC layer is formed of a nonmagnetic material, preferably ruthenium (Ru), that allows the FM1 layer 614 and the FM2 layer 618 to be strongly coupled together antiferromagnetically. A laminated ferromagnetic free layer 622 including a first sublayer 624 and a second sublayer 626 is separated from the AP-pinned layer 612 by a nonmagnetic electrically conducting spacer layer 620. The magnetization of the free layer 622 is preferably parallel to the ABS in the absence of an external field as indicated by the arrow 640 representing the magnetization of the laminated first and second sublayers 624 and 626. A laminated cap layer 628 comprising first and second sublayers 630 and 632, formed on the free layer 622 completes the central region 606 of the SV sensor 600.

(13) The SV sensor 600 further comprises bias layers 642 and 643 formed on the end regions 602 and 604, respectively, for providing a longitudinal bias field to the free layer 622 to ensure a single magnetic domain state in the free layer. Lead layers 644 and 646 are also deposited on the end regions 602 and 604, respectively, to provide electrical connections for the flow of a sensing current I.sub.s from a current source 650 to the SV sensor 600. A signal detector 660 which is electrically connected to leads 644 and 646 senses the change in resistance due to changes induced in the free layer 622 by the external magnetic field (e.g., field generated by a data bit stored on a disk). The external magnetic field acts to rotate the direction of magnetization of